Steam/Water Thermodynamic Properties Calculations Program

(For the FloBoss 103)

User Manual

(QER 04Q018)

Form A6161
March 2008

Revision Tracking Sheet

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This manual may be revised periodically to incorporate new or updated information. The revision date of each page appears at the bottom of the page opposite the page number. A change in revision date to any page also changes the date of the manual that appears on the front cover. Listed below is the revision date of each page (if applicable):

Page	Revision
All pages	Mar-08
All pages	Aug-05
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Initial release	Apr-04

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1 INTRODUCTION

1.1 Scope and Organization

This document serves as the user manual for the Steam and Water Thermodynamic Properties Calculations User Program (QER 04Q018) version 1.30, which is intended for use in a FloBoss™ 103. This manual describes how to download, configure, and monitor this program (referred to as the "Steam/Water Properties program" or "the program" throughout the rest of this manual). You access and configure this program using ROCLINK™ 800 Configuration Software loaded on an IBM-compatible personal computer running Windows® Operating System.

The sections in this manual provide information in a sequence appropriate for first-time users. Once you become familiar with the procedures and the software running in a FloBoss 103, the manual becomes a reference tool.

This manual has the following major sections:

- *Section 1 – Introduction*
- *Section 2 – Installation*
- *Section 3 – Configuration*
- *Section 4 – Reference Materials*

This manual assumes that you are familiar with the FloBoss unit and its configuration. For more information, refer to the following manuals:

- *FloBoss 103 Flow Manager Instruction Manual (Form A6114)*
- *ROCLINK 800 Configuration Software User Manual (Form A6121).*

1.2 Product Overview

The Steam/Water Properties program allows a FloBoss 103 to calculate density, heating value (enthalpy), entropy, viscosity, and specific heat ratio for steam and water applications in either Metric or English (US) units. Program calculations conform to the International Association for the Properties of Water and Steam, International Formulation 1997 (IAPWS-IFC-97) standard. This program is intended for use with a separate flow calculation user program that provides mass and energy flow rates. For a more detailed description of the calculation performed by the program, refer to *Section 4.1 Calculation Details*.

With the program installed, the FloBoss 103 reads the current flowing static pressure and temperature once every second. At start-up, the program sets the Integral Multiplier Period (or IMP) to one minute, the minimum value. At the completion of each IMP, the program executes the Steam and Water Thermodynamic Properties calculations, using the average flowing static pressure and temperature during the IMP. The program writes the resulting values to standard FloBoss 103 point types and point type 31 parameters.

1.2.1 Supported IAPWS Steam and Water Regions

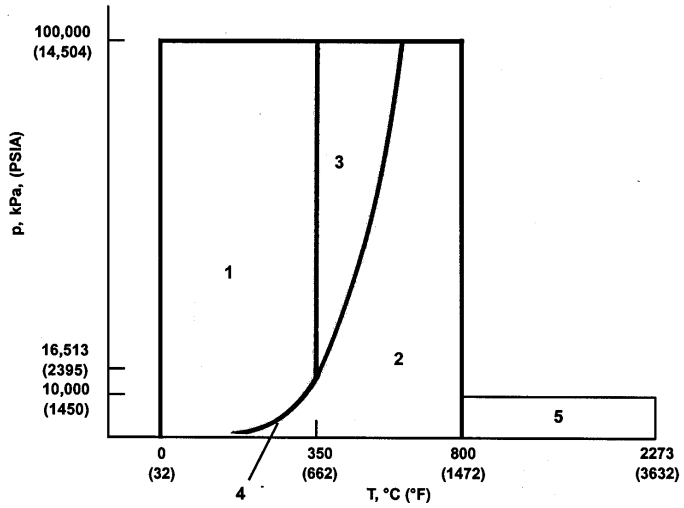

Figure 1. IAPWS Steam and Water Regions 1 through 5

The Steam/Water Properties program supports IAPWS Steam and Water Regions 1, 2, 4, and 5 (see *Figure 1*). The program **does not** support IAPWS Steam and Water Region 3. The steam and water calculations implemented in this user program are valid for pressures between 0.69 and 16513 kPa (0.1 and 2395 PSIA) and temperatures between 0 and 800°C (32 and 1472°F). Calculations of water properties for higher pressures—between 16513 and 100000 kPa (2395 and 14504 PSIA)—are valid for temperatures between 0°C (32°F) and the Region 1 and 3 boundary. Calculations of steam properties for higher pressures—between 16513 and 100000 kPa (2395 and 14504 PSIA)—are valid for temperatures between the Region 2 and 3 boundary and 800°C (1472°F). The calculations are also valid for higher steam temperatures, when the pressure is between 0.69 and 10000 kPa (0.1 and 1450 PSIA). In these cases the temperature can range from 800 to 2000°C (1472 to 3632 °F).

Note: If the static pressure and temperature lie within Region 3, the program sets all of the thermodynamic properties—**including** density, viscosity, specific heat ratio, enthalpy, and entropy—to 1.0 to provide an indication of calculation within this unsupported area.

If you know the fluid is saturated steam or water, the phase can be specified along with the choice of pressure or temperature to use to determine the properties. In this case, the conditions are set to Region 4 and the quality is set to 100% if the phase is specified as saturated steam, and 0% if the phase is specified as saturated water.

1.3 Program Requirements

You download the Steam/Water Properties program to—and then run it from—the Flash and RAM memory on the FloBoss 103. The Steam/Water Properties program is compatible with firmware version 2.12 (or greater) of the FloBoss. Download and configure the program using the ROCLINK 800 Configuration software (version 1.75 or greater).

The downloadable program is:

File Name	Unit	Task	Code	Data
Fb103_iapws_steam.bin	FloBoss 103	User 2	7B0000	4700000

Note: You must connect a PC to the FloBoss 103's Local Operator Interface (LOI) port **before** starting the download.

For information on viewing the memory allocation of user programs loaded in the FloBoss, refer to the *ROCLINK 800 Configuration Software User Manual* (Form A6121).

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2 INSTALLATION

This section provides instructions for installing the Steam/Water Properties program into FloBoss memory. Read Section 1.3 of this manual for program requirements.

2.1 Downloading the Program

This section provides instructions for installing the user program into FloBoss memory.

To download the user program using ROCLINK 800 software:

1. Connect the FloBoss to your computer using the Local Operator Interface (LOI) port.
2. Start and logon to ROCLINK 800.
3. Select ROC > Direct Connect to connect to the FloBoss unit.
4. Select Utilities > User Program Administrator from the ROCLINK menu bar. The User Program Administrator screen displays (see *Figure 2*):

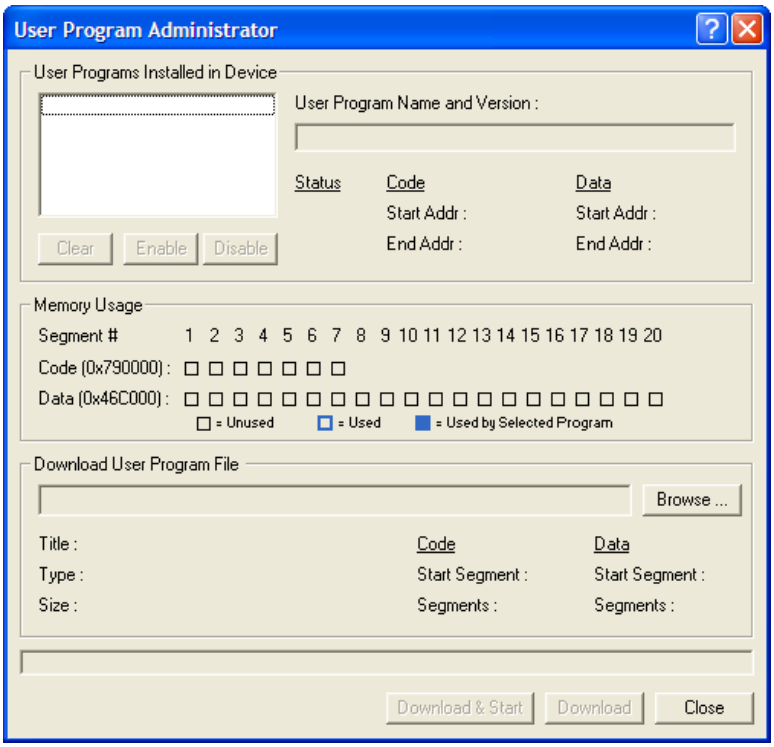

Figure 2. User Program Administrator Screen

5. Click Browse in the Download User Program File frame. The Select User Program File screen displays (see *Figure 3*).
6. Select the path and user program file to download from the CD-ROM. (Program files are typically located in the Program Files folder on the CD-ROM). As *Figure 3* shows, the screen lists all valid user program files with the .BIN extension:

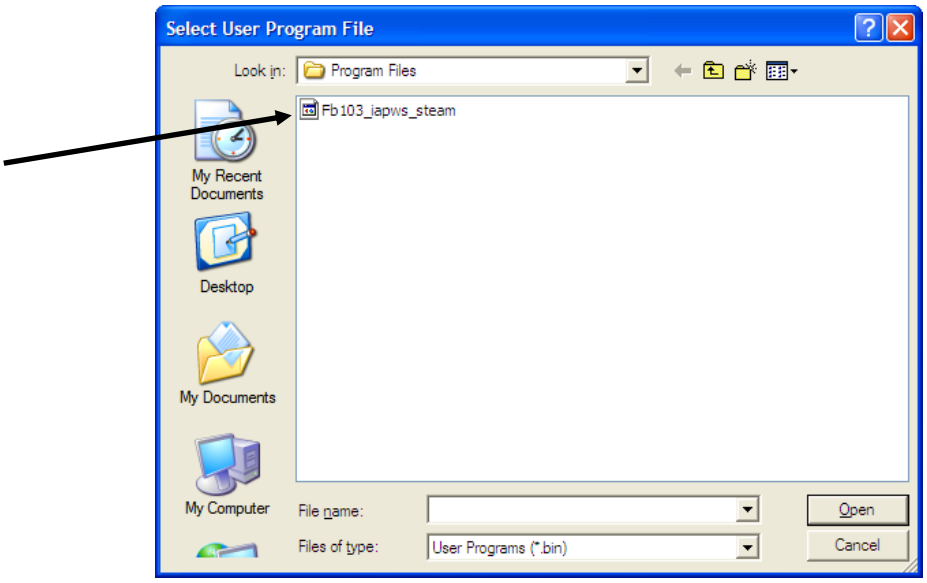

Figure 3. Select User Program File

7. Click Open to select the program file. The User Program Administrator screen displays. As shown in *Figure 4*, note that the Download User Program File frame identifies the selected program and that the Download & Start button is active:

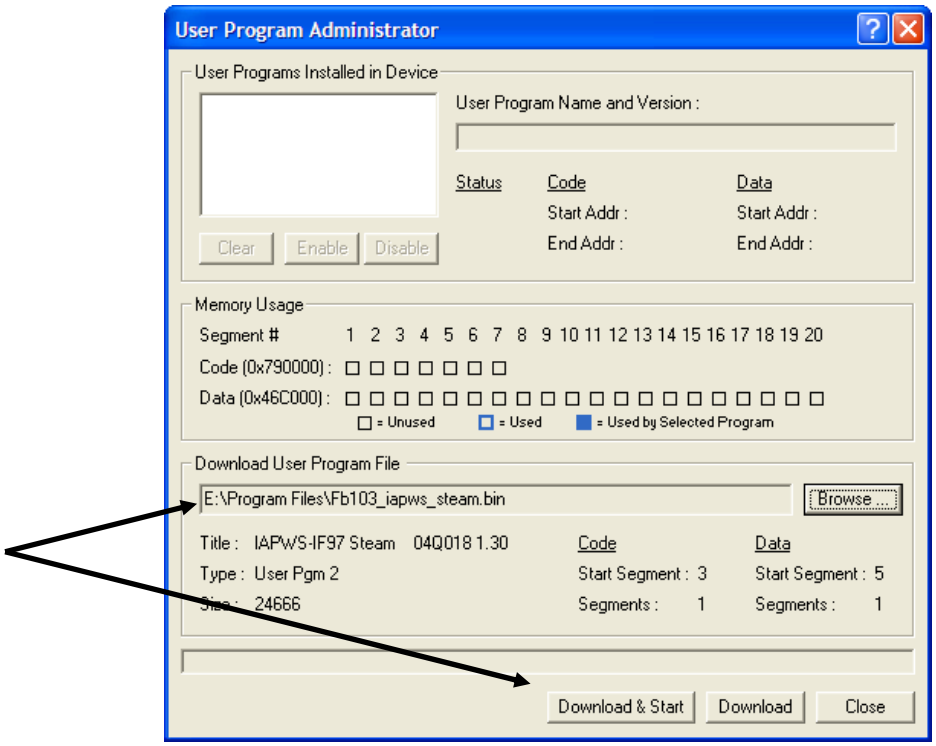

Figure 4. User Program Administrator Screen

8. Click Download & Start to begin loading the selected programs. The following message displays:

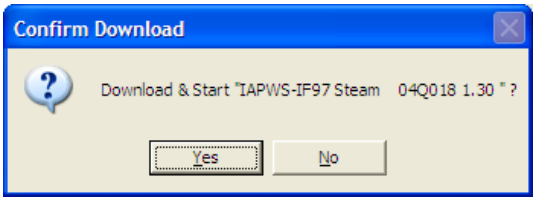

Figure 5. Confirm Download

9. Click Yes to begin the download. During the download, the program performs a Warm Start, creates an event in the Event Log, and—when the download completes—displays the following message:

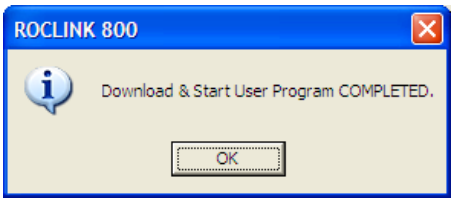

Figure 6. ROCLINK 800 Download Confirmation

10. Click **OK**. The User Program Administrator screen displays (see *Figure 7*). Note that:

- The User Programs Installed in Device frame identifies the loaded program.
- The Status field indicates the program is loaded and running (ON).
- The Memory Usage frame indicates the memory the program uses.

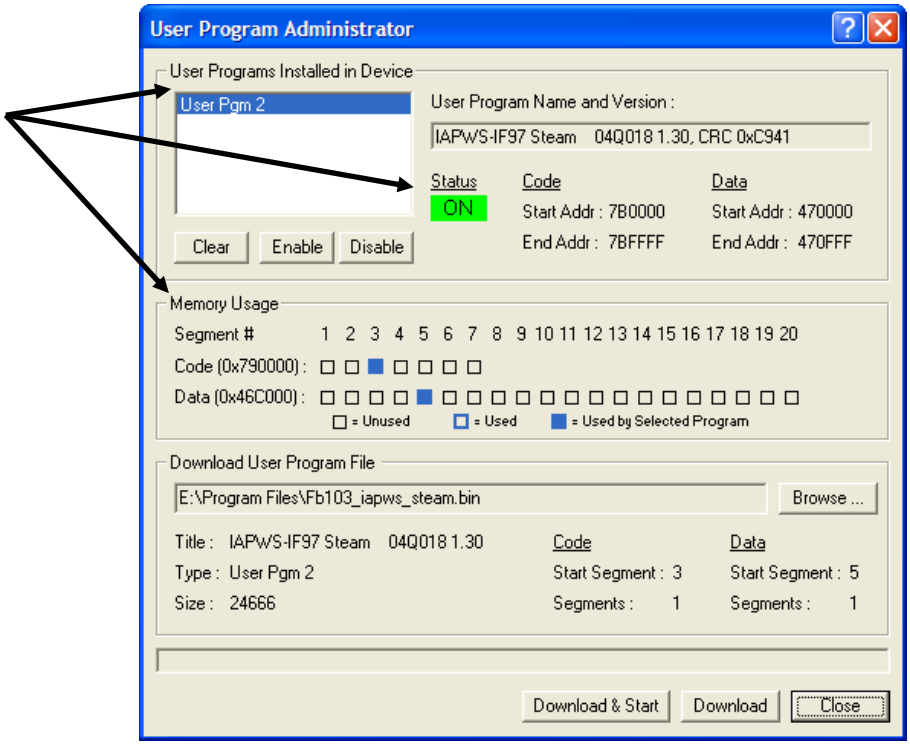

Figure 7. User Program Administrator Screen

11. Click **Close**. The ROCLINK 800 screen displays and the download is complete.

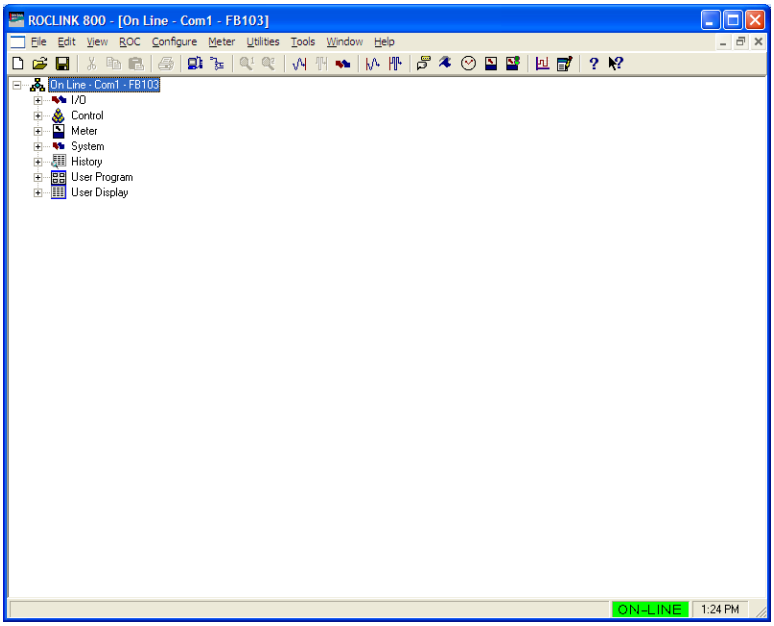

Figure 8. ROCLINK 800 Screen

3 CONFIGURATION

The Steam/Water Properties program requires you to select a phase option on the Steam/Water Properties Setup screen. The flowing pressure and temperature for calculating the steam or water properties are those configured for the FloBoss 103.

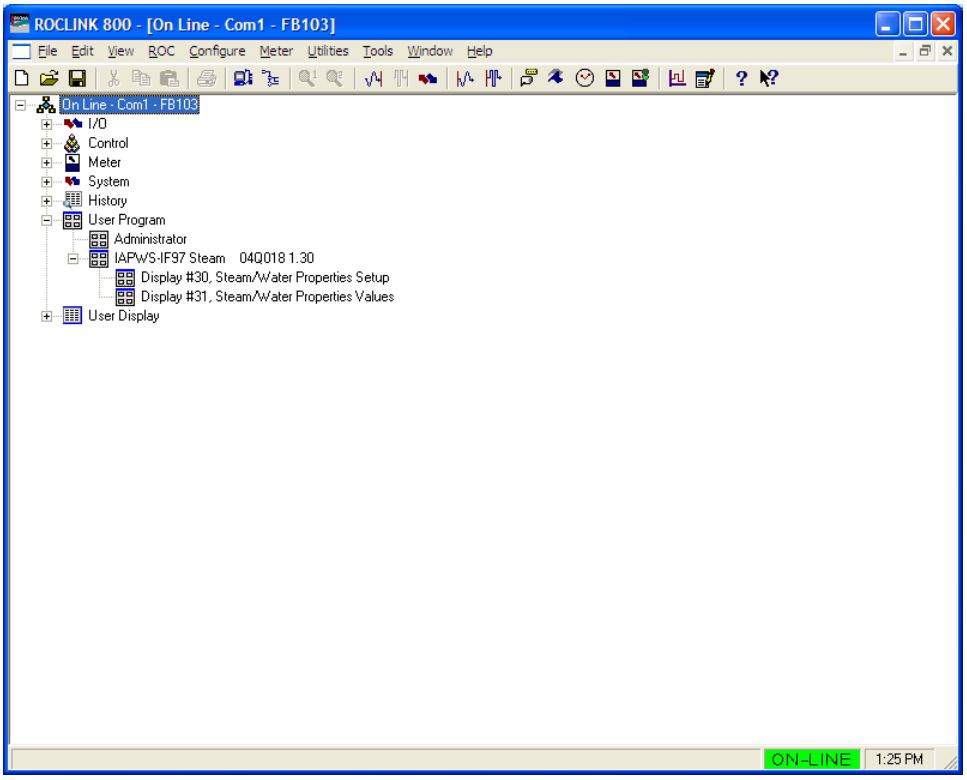

Figure 9. Main ROCLINK800 Screen

3.1 Steam/Water Properties Setup Screen

Use this screen to set the phase option of the fluid being calculated. The phase of the fluid can either be calculated by the program, or the phase of the fluid and the input (temperature or pressure) used in calculations may be specified if the fluid is at saturated conditions.

To access this screen:

1. Select **User Program >IAPW-IF97 Steam 04Q018 1.30.**
2. Double-click **Display #30, Steam/Water Properties Setup**. The Steam/Water Properties Setup screen displays.

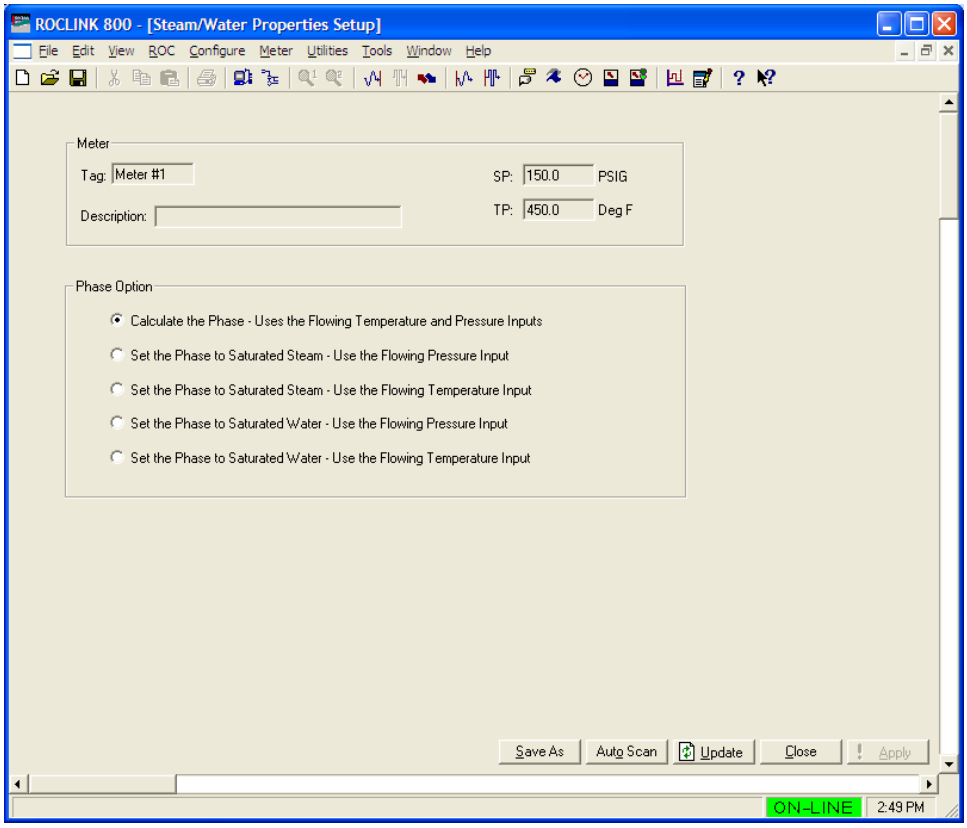

Figure 10. Steam/Water Properties Setup Screen

3. Review the values in the following fields:

Field	Description
Tag	This **read-only** field displays the unique identifier for the meter.
Description	This **read-only** field displays the description associated with this meter.
SP	This **read-only** field displays the flowing static pressure as the fluid passes through the meter. Units are PSIG, PSIA, or kPa.
TP	This **read-only** field displays the flowing temperature as the fluid passes through the meter. Units are Deg F or Deg C.

Phase Option	Sets the method used to determine the phase of the fluid. Valid values are:	
	Calculate the Phase – Uses the Flowing Temperature and Pressure Inputs	The phase is calculated based on the flowing temperature and pressure inputs. If the flowing temperature is within 1.0 Deg C of the saturation temperature for the current flowing pressure, the conditions are considered saturated and the phase is set to gas (steam). This is the **default** selection.
	Set the Phase to Saturated Steam – Use the Flowing Pressure Input	The phase is set to saturated steam and the properties are calculated using the flowing pressure.
	Set the Phase to Saturated Steam – Use the Flowing Temperature Input	The phase is set to saturated steam and the properties are calculated using the flowing temperature.
	Set the Phase to Saturated Water – Use the Flowing Pressure Input	The phase is set to saturated water and the properties are calculated using the flowing pressure.
	Set the Phase to Saturated Water – Use the Flowing Temperature Input	The phase is set to saturated water and the properties are calculated using the flowing temperature.

4. Click **Apply** to save any changes you have made to this screen.

5. Proceed to *Section 3.2* to view the Steam/Water Properties Values screen.

3.2 Steam/Water Properties Values Screen

Use this screen to view the calculation results of the program.

To access this screen:

1. Select **User Program** > **IAPW-IF97 Steam 04Q018 1.30**.
2. Double-click **Display #31, Steam/Water Properties Values**. The Steam/Water Properties Values screen displays.

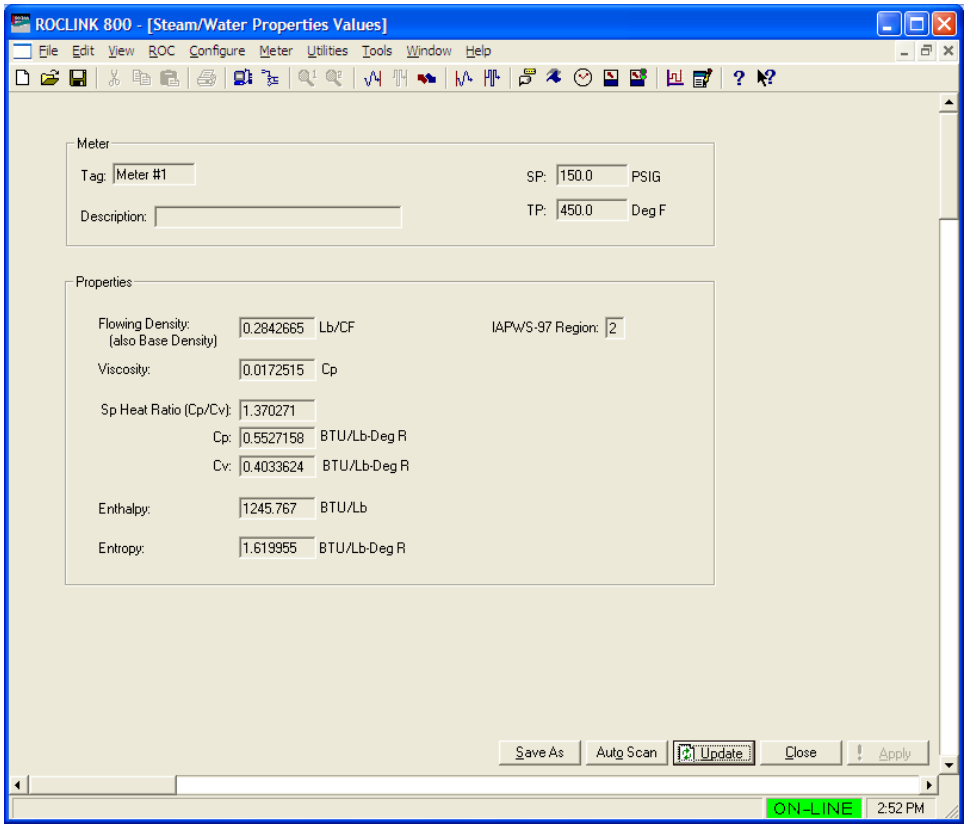

Figure 11. Steam/Water Properties Values Screen

3. Review the values in the following fields:

Field	Description
Tag	This **read-only** field displays the unique identifier for the meter.
Description	This **read-only** field displays the description associated with this meter.
SP	This **read-only** field displays the flowing static pressure as the fluid passes through the meter. Units are PSIG, PSIA, or kPa.
TP	This **read-only** field displays the flowing temperature as the fluid passes through the meter. Units are Deg F or Deg C.
Flowing Density (also Base Density)	This **read-only** field displays the fluid density at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP). Density units are Lb/CF or Kg/M^3. The program sets the density at base conditions to the density at flowing conditions, since setting base conditions for steam and water flow rate measurements is not a common practice.
Viscosity	This **read-only** field displays the calculated viscosity of the steam/water at flowing conditions. Units are Cp.

Field	Description
Specific Heat Ratio (Cp/Cv)	This **read-only** field displays the calculated ratio of specific heats (Cp/Cv) at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP).
Cp	This **read-only** field displays the specific heat (constant pressure) at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP). Units are BTU/Lb-Deg R or kJ/Kg-Deg K.
Cv	This **read-only** field displays the specific heat (constant volume) at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP). Units are BTU/Lb-Deg R or kJ/Kg-Deg K.
Enthalpy	This **read-only** field displays the enthalpy (heating value) at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP). Units are BTU/Lb or MJ/Kg.
Entropy	This **read-only** field displays the entropy at the average flowing pressure and temperature during the previous Integral Multiplier Period (IMP). Units are BTU/Lb-Deg R or kJ/Kg-Deg K.
IAPWS-97 Region	This **read-only** field displays the region (1, 2, 3, 4, or 5, as defined by the standard presented by the International Association for the Properties of Water and Steam, International Formulation 1997) in which the average flowing pressure and temperature resided during the previous IMP. **Notes**: ▪ If conditions reside in Region 3, the message “Region 3 is Not Supported” displays and the program sets the properties values to 1.0. ▪ If conditions reside in Region 4, three additional fields display including either Saturated Steam or Saturated Water (depending on the Phase), Pressure, and Temperature.

4. Proceed to *Section 3.3* to save your configuration.

3.3 Saving the Configuration

Whenever you modify or change the configuration, it is a good practice to save the final configuration to memory.

To save the configuration:

1. Select **ROC** > **Flags**. The Flags screen displays:

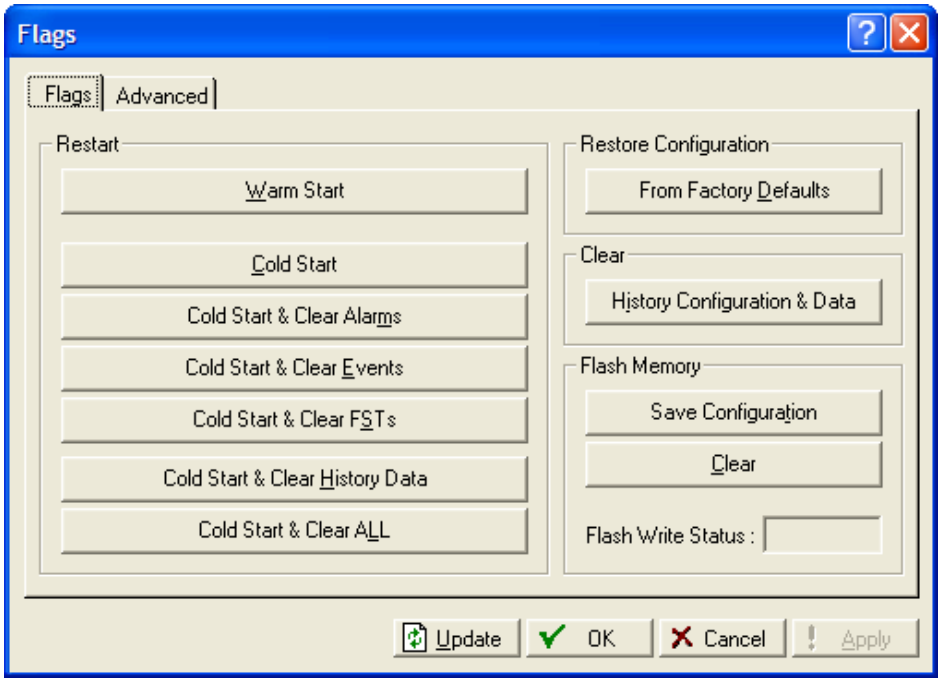

Figure 12. Flags screen

2. Click **Save Configuration**. A verification message displays:

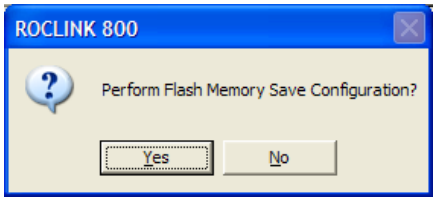

Figure 13. Perform screen

3. Click **Yes** to begin the save process. The Flash Write Status field on the Flags screen displays *In Progress*. When the process ends, the Flash Write Status field on the Flags screen displays *Completed*.
4. Click **Update** on the Flags screen. This completes the process of saving your new configuration.

Note: For archive purposes, you should also save this configuration to your PC's hard drive or a removable media (such as a diskette or a flash drive) using the **File** > **Save Configuration** option on the ROCLINK 800 menu bar.

4 REFERENCE MATERIALS

This section provides a detailed description of the calculation and a list of standard and user-defined point types used by the program.

- Calculation Details
- Point Type 30
- Point Type 31

4.1 Calculation Details

The calculations performed to determine the thermodynamic properties for Regions 1, 2, 4, and 5 are shown in the standard presented by the International Association for the Properties of Water and Steam, International Formulation 1997 (IAPWS-IFC-97). Table 1 shows the parameters and their TLPs used as inputs to the calculation. Table 2 shows the parameters and their TLPs where the results are stored. The parameters in which the program stores the calculated properties are available to the firmware's User C meter flow rate calculation programs.

Table 1. Calculation Input Parameters

Parameter	Definition	TLP
Average Flowing Pressure (Pf)	The average pressure, in PSIA, during the IMP that just ended. The program uses this pressure for the steam/water properties calculations.	47,0,22
Average Flowing Temperature (Tf)	The average temperature, in Deg R, during the IMP that just ended. The program uses this temperature for the steam/water properties calculations.	47,0,23
Units of Measurement	Specifies the units the program uses to express the results of the steam/water properties calculations. Valid values are 0 (US) or 1(metric).	46,0,2,Bit 3 and 15,0,25
Integral Multiplier Period (IMP)	The time period, in minutes, over which the program averages the flowing static pressure and temperature. At the completion of the period, the program uses these averages to calculate the fluid properties. The program sets this value to one minute, the minimum value, on start up.	46,0,6
Phase Option	Specifies the option used for determining the phase of the fluid and calculating the properties. Valid values are:	30,0,0
	0 The phase is calculated based on the flowing temperature and pressure inputs. If the flowing temperature is within 1.0 Deg C of the saturation temperature for the current flowing pressure, the conditions are considered saturated and the phase is set to gas (steam).	
	1 The phase is set to saturated steam and the properties are calculated using the flowing pressure.	
	2 The phase is set to saturated steam and the properties are calculated using the flowing temperature.	
	3 The phase is set to saturated water and the properties are calculated using the flowing pressure.	
	4 The phase is set to saturated water and the properties are calculated using the flowing temperature.	

Table 2. Calculation Results Parameters

Parameter	Definition	TLP
IAPWS-IFC-97 Region in which the flowing conditions of the fluid reside.	Valid regions are **1**, **2**, **4**, and **5**. If conditions reside in Region 3, the program sets the value of each of the properties to 1.0.	31,0,0
Entropy	The entropy of the fluid at flowing conditions. Units are BTU/Lb-Deg R or kJ/Kg-Deg K.	31,0,1
Cp	The specific heat at constant pressure at flowing conditions. Units are BTU/Lb-Deg R or kJ/Kg-Deg K.	31,0,2
Cv	The specific heat at constant volume at flowing conditions. Units are BTU/Lb-Deg R or kJ/Kg-Deg K.	31,0,3
Temperature Used for Properties	The actual temperature used to determine fluid properties. Units are Deg F or Deg C.	31,0,4
Pressure Used for Properties	The actual pressure used to determine fluid properties. Units are PSIA, PSIG, or kPa.	31,0,5
AGA Enable Status	Valid values are **0** (AGA8 Disabled) and **1** (AGA8 Enabled). The program sets this value to **0**, which prevents the FB103 firmware from calculating the fluid properties using the AGA8 properties calculations.	46,0,2,Bit 0
Heating Value Basis	Valid values are **0** (Mass Basis) and **1** (Volume Basis). The program sets this value to **0** so the units of the enthalpy are always energy/mass.	46,0,4,Bit 6
Enthalpy (Heating Value)	The enthalpy of the fluid at flowing conditions. Units are BTU/Lb or MJ/Kg.	46,0,17
Viscosity, in Cp	The viscosity of the fluid at flowing conditions. Units are Cp.	46,0,18
Specific Heat Ratio, Cp/Cv	The ratio of specific heats (Cp/Cv) of the fluid at flowing conditions.	46,0,19
Density at flowing conditions	The density of the fluid at flowing conditions. Units are Lb/CF or Kg/M^3.	47,0,24
Density at base conditions	The program sets the density at base conditions to the density at flowing conditions, since setting base conditions for steam and water flow rate measurements is not a common practice. Units are Lb/CF or Kg/M^3.	47,0,25

4.2 Point Type 30: Properties Setup

Point type 30 contains the parameters for configuring the program.

Point Type 30 – Properties Setup				
Para-meter #	**Read-Write**	**Data Type**	**Length**	**Description**
0	R/W	UINT8	1	Phase Option. Specifies the option used for determining the phase of the fluid and calculating the properties. Valid values are: 0 = The phase is calculated based on the flowing temperature and pressure inputs. If the flowing temperature is within 1.0 Deg C of the saturation temperature for the current flowing pressure, the conditions are considered saturated and the phase is set to gas (steam). 1 = The phase is set to saturated steam and the properties are calculated using the flowing pressure. 2 = The phase is set to saturated steam and the properties are calculated. 3 = The phase is set to saturated water and the properties are calculated using the flowing pressure. 4 = The phase is set to saturated water and the properties are calculated using the flowing temperature.

4.3 Point Type 31: Properties Values

All of the calculated values not stored to standard FloBoss meter run point types (point types 46 and 47) are stored to point type 31.

Point Type 31 – Properties Values				
Para-meter #	**Read-Write**	**Data Type**	**Length**	**Description**
0	R/O	UINT8	1	IAPWS-IF97 Region.
1	R/O	FLP	4	Entropy (BTU/Lb-Deg R or kJ/Kg-Deg K).
2	R/O	FLP	4	Cp – specific heat at constant pressure (BTU/Lb-Deg R or kJ/Kg-Deg K).
3	R/O	FLP	4	Cv – specific heat at constant volume (BTU/Lb-Deg R or kJ/Kg-Deg K).
4	R/O	FLP	4	Temperature used in properties calculations (Deg F or Deg C).
5	R/O	FLP	4	Pressure used in properties calculations (PSIA, PSIG, or kPa).

If you have comments or questions regarding this manual, please direct them to your local sales representative or contact:

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